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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

APPLICATION FOR U.S. LETTERS PATENT

Title:

A METHOD, SYSTEM, AND APPARATUS FOR SECURING A SECTION OF A VERTICAL STACK OF GENERALLY FLAT SHEETS, CARTONS, AND LIKE

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A METHOD, SYSTEM, AND APPARATUS FOR SECURING A SECTION OF A VERTICAL STACK OF GENERALLY FLAT SHEETS, CARTONS, AND LIKE

BACKGROUND OF THE INVENTION

[0001] The present invention generally relates to a method, system and apparatus for securing a section of a vertical stack of generally flat product. More particularly, the invention is directed to a system, method and apparatus for separating and transporting a collection of stacked objects from a stack with a depalletizing apparatus having a suction device assembly, a probing tongue, a lifting blade and optionally a compression arm assembly.

[0002] A stack of flat product must be depalletized at some point in order for them to pass through to the next manufacturing process. The height of the stack that is picked is often limited by the loading capability of the next process machine, requiring that only portions of the column be picked at a time. This depalletization is often done manually because it has not been possible to pick up portions of the columns without damaging the cartons in some manner.

[0003] Stacks of cartons have been depalletized in the past by making special dividers from plastic or metal. The dividers would have a corrugated surface that would allow pickings fingers to be inserted under a stack of cartons and lift them vertically. These dividers are an expense and must be reused and stored in order to be cost effective. When the stacks are depalletized manually, excess carton material is often used for the slip sheets, thus utilizing what is otherwise scrap material. The manual process, for example, utilizes a fork lift that inserts the lifting blade into the stack near the divider. The unfortunate result of direct insertion of a lifting blade into the stack is that a number of the product will be damaged.

[0004] Thus an improved method, system and apparatus is needed for depalletizing stacked product so as to minimize damage to the stacked product during insertion of a lifting blade.

BRIEF SUMMARY OF THE INVENTION

[0005] In one embodiment of the invention there is a depalletizing apparatus for separating and transporting a collection of stacked objects from a stack. The stacked objects include cardboard boxes, stacked paper, stacked cartons or other generally flat products. The apparatus comprises a suction device assembly for lifting an edge portion of a stack of objects in a substantially vertical direction. The suction device assembly includes a vacuum cup attached to an arm member. The arm member is preferably rigid and disposed in a vertical axis. The

depalletizing apparatus includes a probing tongue for insertion into the stack at a position at or below the suction device assembly, such that after insertion into the stack, the stacked objects above the probing tongue define a collection of stacked objects. The depalletizing apparatus includes a lifting blade for vertically lifting the collection of stacked objects. The apparatus may further comprise a compression device assembly for applying a downward compression force utilizing a compression foot on an uppermost stacked object for stabilizing the collection of stacked objects during movement. The suction device assembly may include one or more suction cups that are operably connected to a suction or vacuum generating source. Preferably the suction device assembly, the lifting blade and the compression device are each moveable in x-, y- and z- axes.

[0006] In another embodiment of the invention there is a robotic assembly for separating and transporting a collection of stacked objects from a stack. The stacked objects include cardboard boxes, stacked paper, stacked cartons, or other generally flat products. The robotic assembly includes a robotic mechanism providing a range of motion, and a frame connected to the robotic mechanism. A suction device assembly for vertically lifting an edge portion of a stack of objects is operably connected to the frame. The suction device assembly may have one or more suction cups operably connected to a suction producing source. A lifting blade is operably connected to the frame. A probing tongue connected to the lifting blade with the probing tongue is moveable into the stack at a position at or below the suction device assembly. After insertion of the probing tongue into the stack, the stacked objects above the probing tongue define a collection of stacked objects.

[0007] The robotic assembly may further comprise a compression device assembly for applying a downward compression force on the collection of stacked object for stabilizing the collection of stacked objects during movement. Preferably the suction device, the lifting blade and the compression device are each moveable in x-, y- and z- axes.

[0008] The present invention includes a method for separating and transporting a collection of stacked objects from a stack. The method generally includes the steps of vertically lifting an edge portion of a plurality of objects in a stack by utilizing a suction force; inserting a probing tongue into the stack at a position at or below the vertically lifted edge portion, such that after insertion into the stack, the stacked objects above the probing tongue define a collection of stacked objects, and such that an opening in a side of the stack is made; inserting a lifting blade into the opening; and vertically lifting the collection of stacked objects with said lifting blade. The suction force may be applied by a suction device assembly as described herein.

[0009] A downward force is applied on the uppermost stacked object to compress said collection of stacked objects. This may be done by moving a compression foot of a compression arm assembly downward on the uppermost stacked object.

[0010] The foregoing has outlined rather broadly the features and technical advantages of the present invention in order that the detailed description of the invention that follows may be better understood. Additional features and advantages of the invention will be described hereinafter which form the subject of the claims of the invention. It should be appreciated that the conception and specific embodiment disclosed may be readily utilized as a basis for modifying or designing other structures for carrying out the same purposes of the present invention. It should also be realized that such equivalent constructions do not depart from the invention as set forth in the appended claims. The novel features which are believed to be characteristic of the invention, both as to its organization and method of operation, together with further objects and advantages will be better understood from the following description when considered in connection with the accompanying figures. It is to be expressly understood, however, that each of the figures is provided for the purpose of illustration and description only and is not intended as a definition of the limits of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] For a more complete understanding of the present invention, reference is now made to the following descriptions taken in conjunction with the accompanying drawing, in which:

[0012] FIG. 1 is a perspective view of a pallet having stacked flat product;

[0013] FIG. 2 is a plan view of the present invention representing the general operating context of the inventive device;

[0014] FIG. 3 is a top view of a probing tongue and lifting blade taken generally along line 3-- 3 in FIG. 2;

[0015] FIG. 4 is a plan view of the present invention illustrating forming a separation of stacked objects;

[0016] FIG. 5 is a plan view of the present invention illustrating insertion of the probing tongue into the stack;

[0017] FIG. 6 is a plan view of the present invention illustrating insertion of the lifting blade into the stack;

[0018] FIG. 7 is a plan view of the present invention operable connected to a conveyance means; and

[0019] FIG. 8 is a plan view of the present invention operable connected to a robot arm assembly.

[0020] It should first be noted that, upon review of the detailed description and the drawings provided herein, it will become apparent to one of ordinary skill in the material handling, robotics, or other relevant art, that the present invention is also applicable to material handling processes and equipment other than those specifically described herein. For example, a robotic implement according to the present invention may be used with other robotic mechanisms known in the art. Further, the method described herein may be applicable to other objects besides a stack of paper or cardboard. The present invention is not intended to be limited to the structures and methods specifically described and illustrated herein.

DETAILED DESCRIPTION OF THE INVENTION

[0021] FIG. 1 illustrates a collection of stacked product **1**. A pallet **2** carries the stacked flat product **3**. These stacks may include carton blanks, disassembled cardboard boxes, stacked paper, disassembled stacked cartons and other generally flat materials. Depending on the size of the product **3**, there may be from one to twenty columns on the pallet **2**. Slip sheets **4** (often referred to as tie sheets) are placed in the columns at various levels to stabilize the columns. Typically, the generally flat materials all have the same shape or configuration. In the simplest form, this configuration is a square or other rectangle having four straight edges. In many applications, however, this configuration is a polygon having more than four edges. Preferably, the present invention is utilized with generally flat, uniformly-configured items.

[0022] Referring now to FIG. 2, a depalletizing apparatus for separating and transporting a collection of stacked product from a stack is shown. The depalletizing apparatus includes four components: a suction device assembly **10**, a probing tongue **16**, a lifting blade **19** and an optional compression arm assembly **21**.

[0023] The suction device assembly **10** includes a vacuum cup **14** attached to an arm member **12** which is preferably rigid in its structure. In one embodiment, the arm member is disposed in a generally vertical axis. In an alternate configuration, the arm member **12** may be generally horizontally disposed. To allow placement of the vacuum cup **14** against the face of

the stacked product **1**, the arm member is moveable in all three dimensions, i.e. the -x, -y, and -z axes.

[0024] The vacuum cup **14** preferably has a conically-shaped face made from a semi-rigid material, like rubber. The semi-rigid material allows the vacuum cup **14** to flex when pushed against the side of the stack so as to reduce damage to the stacked product. The vacuum cup **14** may also have a softer flexible lip bordering the face of the vacuum cup **14** to provide an improved seal with the side of the stack **1**. The vacuum cup **14** is operably coupled via a hose **13** or other tubing to a vacuum or other suction producing source (not shown).

[0025] A stack sensor **11** is mounted on the suction device assembly **10**. Preferably, the stack sensor **11** is mounted on the arm member **12** adjacent to the top of the vacuum cup **14**. As the arm member **12** moves forward toward the stack **1**, the stack sensor **11** determines the sensor's position in relation to the face of the stacked product **1**. The position of the vacuum cup **14** can then be determined based on the position of the stack sensor **11** to the stack. The stack sensor **11** preferably is a device that utilizes an infrared signal that is projected from the device, such a sensor type is well known to those skilled in the art. The signal is reflected from the side of the stack and the signal return time is computed into a linear distance. Other well known devices that can determine the distance of a surface from a device may be utilized as the stack sensor, such as laser, optical or radio wave devices.

[0026] The lifting blade **19** and the probing tongue **16** work together for insertion of the lifting blade into the stacked product **1**. The probing tongue **16** is attached via a hinge **17** to an arm **18**. The arm **18** is moveable in a horizontal direction to move the probing tongue **16** forward and backward in relation to the tip **26** of the lifting blade **19**. The lifting blade **19** is independently moveable from the probing tongue **16** in a horizontal direction. Both the arm **18** and the lifting blade **19** are preferably interconnected to a frame.

[0027] Referring now to FIG. 3, a top view of the probing tongue and lifting blade taken generally along line 3-- 3 in FIG. 2 is shown. In one embodiment, the lifting blade is a single blade. The particular width and length of the blade **19** utilized should correspond generally to the width and length of the column of stacked product **1** to be lifted. In an alternate embodiment, the lifting blade includes two or more forks that are adjustable in width.

[0028] Referring back to FIG. 2, the compression arm assembly **21** is an optional component of the depalletizing apparatus. The compression arm assembly **21** provides vertical stability during movement of a collection of stacked product. Preferably, the compression arm assembly **21** has as piston housing **22** that includes a hydraulically actuated piston **23**. A piston

shaft **24** is attached to the piston **23** and a compression foot **25** is attached to the piston shaft **24**. The **25** compression foot preferably has a planar surface that contacts the stacked product. The compression arm assembly **21** is preferably moveable in the -x, -y, and -z axes, thereby allowing the compression arm assembly to be maneuvered to a center portion of the collection of stacked product. The compression arm assembly is actuated and the compression foot **25** is pressed downward on the top of the stacked product **1**.

[0029] Referring now to FIG. 4., in the operation of the present invention, the suction device assembly **10** is moved forward towards the stacked product **1** until the face of the vacuum cup **14** touches the column of the stacked product **1**. A suction force is applied to the side of the stack product **1** via the vacuum cup **14**. While maintaining the suction force, the suction device assembly **10** moves generally in the direction of arrow **28**. The edge of the stacked product is lifted thereby lightening the load of the side of the stack and allowing the probing tongue **16** to be inserted into the stack proximate or juxtapose the slip sheet **4**. In this manner, the probing tongue **16** may be advanced from the slip sheet **4,** or into opening **30**, without damaging any of the stacked materials since substantially all of the weight has been taken off the edge of the slip sheet by the suction device assembly **10**.

[0030] A tongue sensor **20** is mounted on the suction device assembly **10**. Preferably, the tongue sensor **20** is mounted on the arm member **12** adjacent to the bottom of the vacuum cup **14**. As the probing tongue **12** moves upward toward the suction device assembly **10**, the tongue sensor **20** determines the sensor's position in relation to the top of the probing tongue **12**. The position of the probing tongue **16** can then be determined based on the position of the tongue sensor **20** to the probing tongue **16**. The stack sensor **11** preferably is a device that utilizes an infrared signal that is projected from the device, and is well known to those skilled in the art. The signal is reflected from the side of the stack and the signal return time is computed into a linear distance. Other well known devices that can determine the distance of a surface from a device may be utilized as the stack sensor, such as such as laser, optical or radio wave devices.

[0031] As shown in FIGS. 5 & 6, the probing tongue **16** is maneuvered below the suction device assembly **10** and inserted into the stacked product **1**. The probing tongue may be inserted in to the opening **30**, or below the suction assembly device into the stacked product **1** since the weight of the side of the stacked product **1** is lightened. The product above the probing tongue **16** defines a collection of product that is to be removed from the stack **1**. The probing tongue **16** is moveable into the stack **1** for further opening the stack for insertion of the lifting blade **19** by the advancement of the lifting blade **19** in the direction of arrow **29** against the probing tongue

16. The lifting blade 19 is moved forward into the stack in the direction of arrow 32 while the probing 16 tongue maintains an opening for the lifting blade 19. The probing tongue 16 is retracted allowing the lifted edge of the stacked product to settle down on the lifting blade 19.

[0032] The optional compression arm assembly may be actuated via hydraulic fluid in the direction of arrow 31. This causes the compression foot 25 to move downward on the stack. The collection of stacked product is lifted by the lifted blade 32 and moved off of the pallet for further handle or processing.

[0033] Referring now to FIG. 7, a plan view of the depalletizing apparatus operably connected to a vehicle is shown. In this embodiment, a suction device assembly 10, a probing tongue 16, lifting blade 19, and an optional compression arm assembly 21 are coupled to frame 52. The frame 52 is connected to the conveyance means 51, such as a fork lift, via support member 45. A piston rod 47 connected the frame 52 to piston 46 which connected to the support member 45. Actuation of piston 46 moves the frame 52 in a generally vertical direction. The support member 45 is hingedly attached to the conveyance means 51. Piston 50 is connected to the conveyance means 51. Piston rod 49 is connected to the support member 45. Actuation of piston 50 allows tilting of the frame assembly 52. Preferably, piston 46 and 50 are hydraulically driven and may also be referred to as hydraulic cylinders.

[0034] An arm housing 53 encloses a portion of the arm 12 of the suction device assembly 10. The arm housing 53 is connected to the frame 52 and the housing 53 is moveable in a generally vertical and horizontal direction by pistons 33 and 36 respectively. Piston rod 33 is connected to arm 12. Actuation of piston 33 vertically moves arm 12. The arm housing 53 is connected to the frame 52 and moves in a horizontal direction via track 35. A piston rod 37 connects the arm housing 53 to cylinder 36.

[0035] The probing tongue 16 is connected to arm 18. The horizontal moveable arm 18 is connected to the piston rod 40 connected to cylinder 41.

[0036] The lifting blade 19 is disposed within a portion of the frame 52. Pressure wheel 42 interfaces with the lifting blade 19. The pressure wheel rotates to horizontally move the lifting blade 19. The lifting blade moves with the aide of rollers 43 and 44. In lieu, of the pressure wheel, a toothed-sprocket may be utilized where the lifting blade 19 has recessed openings where the toothed-sprocket and recessed openings cooperate to move the lifting blade 19.

[0037] The optional compression arm assembly 21 is horizontally moveable via track 38. Piston rod 39 connects the compression arm assembly 21 to piston 40. The compression arm assembly operates as discussed above.

[0038] Preferably, cylinders **33, 36, 40, 41, 46** and **50** are hydraulically actuated.

[0039] The depalletizing apparatus shown in FIG. 7 operates generally as described for FIGS. 1 – 4 above. After the weight of the side of the stacked product is lightened by the suction device assembly, the probing tongue **16** is maneuvered below the suction device assembly **10** and inserted into the stack. The product above the probing tongue **16** defines a collection of product that is to be removed from the stack. The probing tongue **16** is moveable into the stack for further opening the stack for insertion of the lifting blade **19** by the advancement of the lifting blade **19** against the probing tongue **16**. The lifting blade **19** is moved forward into the stack while the probing **16** tongue maintains an opening for the lifting blade **19**. The probing tongue **16** is retracted allowing the lifted edge of the stacked product to settle down on the lifting blade **19**. Optionally, the compression arm assembly **21** may be actuated causing the compression foot **25** to move downward on the stack. The collection of stacked product is lifted by the lifted blade **32** and moved off of the pallet for further handle or processing.

[0040] Referring now to FIG. 8, a plan view of the robotic arm assembly operably connected to the depalletizing apparatus is shown. For purposes of this embodiment, reference numbers have been increased by 100. A suction device assembly **110**, a probing tongue **116**, lifting blade **119,** and an optional compression arm assembly **121** are coupled to frame **152**. The frame **152** is coupled to a robotic mechanism providing a range of motion for the frame **152**. Preferably, the robotic mechanism provides movement of the frame **152** in an x-, -y and -z axes, and rotates the frame in horizontally 360 degrees. The robotic mechanism is comprised of beam member **161** connected to a connection arm **163**. The beam member slides on a beam **162.** The beam member is connected to piston rod **165** which is connected to piston **164**. Actuation of the piston **164** provide horizontal movement of the beam member **161** and correspondingly horizontally moves the frame **152**. The beam member **161** and the frame **152** have flanges **166** and **167** respectively. Connection arm **163** is hingedly attached to the flanges **166, 167** via joints **168** and **169**. Pistons **170** and **172** provide vertical and tilting movement of the frame **152** through via piston rods **171** and **173**. Preferably, flange **166** is rotatable so as to rotate the frame **152** interconnected thereto.

[0041] By utilizing various combinations of joints and rotations about these joints, robotic assembly may be programmed or otherwise operated to move through a full range of linear and angular motion.

[0042] An arm housing **153** encloses a portion of the arm **112** of the suction device assembly **110**. The arm housing **153** is connected to the frame **152** and the housing **153** is

moveable in a vertical and horizontal direction by pistons **133** and **136** respectively. Piston rod **133** is connected to arm **112**. Actuation of piston **133** vertically moves arm **112**. The arm housing **153** is connected to the frame **152** and moves in a horizontal direction via track **135.** A piston rod **137** connects the arm housing **153** to cylinder **136**. Preferably, cylinders **133** and **136** are hydraulically actuated.

[0043] The probing tongue **116** is connected to arm **118**. The horizontal moveable arm **118** is connected to the piston rod **140** connected to cylinder **141**.

[0044] The lifting blade **119** is disposed within a portion of the frame **152**. Pressure wheel **142** interfaces with the lifting blade **119**. The pressure wheel rotates to horizontally move the lifting blade **119**. The lifting blade moves with the aide of rollers **143** and **144**. In lieu, of the pressure wheel, a toothed-sprocket may be utilized where the lifting blade **119** has recessed openings where the toothed-sprocket and recessed openings cooperate to move the lifting blade **119**.

[0045] The optional compression arm assembly **121** is horizontally moveable via track **138**. Piston rod **139** connects the compression arm assembly **121** to piston **140**. The compression arm assembly operates as discussed above.

[0046] Preferably, the cylinders are hydraulically actuated. However, an electro-mechanical device may be used in place of the hydraulic cylinders.

[0047] The depalletizing apparatus shown in FIG. 8 operates generally as described for FIGS. 1 – 4 above. After the weight of the side of the stacked product is lightened by the suction device assembly, the probing tongue **116** is maneuvered below the suction device assembly **110** and inserted into the stack. The product above the probing tongue **116** defines a collection of product that is to be removed from the stack. The probing tongue **116** is moveable into the stack for further opening the stack for insertion of the lifting blade **119** by the advancement of the lifting blade **119** against the probing tongue **116**. The lifting blade **119** is moved forward into the stack while the probing **116** tongue maintains an opening for the lifting blade **119**. The probing tongue **116** is retracted allowing the lifted edge of the stacked product to settle down on the lifting blade **119**. Optionally, the compression arm assembly **121** may be actuated causing the compression foot **125** to move downward on the stack. The collection of stacked product is lifted by the lifted blade **132** and moved off of the pallet for further handle or processing.

[0048] Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions and alterations can be made herein without departing from the invention as defined by the appended claims. Moreover, the scope of

the present application is not intended to be limited to the particular embodiments of the process, machine, manufacture, composition of matter, means, methods and steps described in the specification. As one will readily appreciate from the disclosure, processes, machines, manufacture, compositions of matter, means, methods, or steps, presently existing or later to be developed that perform substantially the same function or achieve substantially the same result as the corresponding embodiments described herein may be utilized. Accordingly, the appended claims are intended to include within their scope such processes, machines, manufacture, compositions of matter, means, methods, or steps.